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Determining the Effects of Reflection Type and Cognitive Style on Students' Content Knowledge

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Abstract

The purpose of this exploratory, experimental study was to determine the effects that the type of reflection-in-action and students' cognitive style had on content knowledge of preservice agriculture teachers (N = 57) at Oklahoma State University. Students' cognitive style was assessed using Kirton's Adaptation-Innovation Inventory (KAI). Students were classified as either more adaptive *or* more innovative. *Students were assigned randomly to either a verbal or written reflection-in-action group in the completely randomized 2x2 design. A Lab Aids® classroom kit, based on the principles of biofuels, served as the content for the treatment. The findings of this study indicated that cognitive style and type of reflection-in-action did not affect students' knowledge scores in an agriscience laboratory positively or negatively. As such, teachers can utilize either type of reflection-in-action without detriment to student learning. As this study was exploratory in nature, it is recommended that it be replicated with a larger sample size to increase generalizability. Additional research should focus on pairing students of similar and opposite cognitive styles to determine how their problem-solving ability and performance on tests is affected.*

Keywords: Agricultural Education, Cognitive Style, Problem Solving Style, Reflection, Reflection-in-action,

Fundamentally, agricultural education has focused on helping students solve real-world problems by providing experiences that are both hands-on and minds-on (Moore & Moore, 1984; Parr & Edwards, 2004; Shoulders & Myers, 2012). Agricultural education's problem solving philosophy can be traced to John Dewey and his work on reflective thinking (Phipps, Osborne, Dyer, & Ball, 2008). In fact, the problem solving approach has evolved as the preferred teaching method in agricultural education (Phipps et al., 2008). The importance of solving problems continues to be relevant in today's educational climate, as problem solving skills have been identified as necessary for employment in various sectors of the agricultural industry (Robinson & Garton, 2008). Additionally, Shoulders and Myers (2012) stated, "Trends in the agriculture industry signal a need for agricultural education to teach scientific problem solving" (p. 124).

Since the genesis of agricultural education, the integration of science has been a topic of discussion and debate among educators. It has been suggested that students at the secondary level learn science better if it is taught in the context of agriculture (Parr & Edwards, 2004; Pearson, Young, & Richardson, 2013; Thompson & Balschweid, 2000). Further, empirical evidence exists that when science is taught in context of agriculture, students learn agriculture at a higher level (Haynes, Robinson, Edwards, & Key, 2012). Specifically, Haynes et al. (2012) found a

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statistically significant effect in agricultural content knowledge in favor of those who were taught agriculture from a science-enhanced curriculum when compared to those who were not.

Teaching science in agriculture is not a new phenomenon. The content focus trends in agricultural education have evolved from as early as the 1900s to present day, coming full circle back to science integration (Wilson & Curry, 2011). There exists a growing call for the integration of science, technology, engineering, and mathematics (STEM). This was highlighted in the 2005 *Nation's Report Card* which revealed that, although science and math scores show an increase in knowledge, "the large majority still fail to reach adequate levels of proficiency" (Kuenzi, 2008, p. 1). Agricultural educators have made this initiative a priority at the local, state, and national levels (Doerfert, 2011). The focus of STEM principles taught in an agricultural context allows for "increased rigor and expectations" (Wilson & Curry, 2011, p. 140).

Emphasis of science content in agriucultural education is not a new phenomenon. Dormody (1993) conducted a national study of science crediting in agricultural education and reported that 34% of teachers from 33 states taught at least one agriculture course that counted as a secondary science credit. The National FFA Organization (n.d.) promotes the integration of STEM principles in the areas of SAE, Agriscience Fair, and career development events. There exists an obvious connection between science and agriculture, as agriculture has been proclaimed to be "the world's oldest science" (Ricketts, Duncan, and Peake, 2006, p. 48).

Historically, teacher-centered instructional strategies, whereby the teacher acts as the authority figure and uses drill procedures to help students memorize information, were deemed the preferred method of delivering instructional content in common education (Moore & Moore, 1984). However, throughout the years, those strategies have been questioned. Student-centered methods of instruction, such as (a) inquiry-based learning, (b) problem solving, and (c) experiential learning, have reversed the trend of teachers dominating the learning environment (Phipps et al., 2008). Student-centered methods put the students at the helm of their own learning while the teacher acts as a facilitator of the learning experience rather than an authority figure (Thoron & Myers, 2012). This method of delivery has been preferred in science because, when students believe they are in control of their education, they tend to exert greater effort in learning and become better at solving problems (Parr & Edwards, 2004; Schunk, 2012).

Teaching methods, such as (a) inquiry-based, (b) problem solving, or (c) experiential learning, that incorportate concrete, contextual experiences hold promise for increasing student achievement (Parr & Edwards, 2004). Further, agricultural education laboratories are natural settings for teachers to utilize instructional methods that encourage student to practice solving problems (Phipps et al., 2008). Agricultural laboratories, which can include (a) food science, (b) animal science, (c) agricultural mechanics, (d) horticulture, and (e) aquaculture labratories, among others, provide a rich environment for inquiry-based learning and the application of instructional principles (Phipps et al., 2008). Inquiry-based instruction encompasses multiple dimensions of teaching and learning which demands that learners develop deep cognition while associating content knowledge to solving problems (Parr & Edwards, 2004). Incorporating laboratory experiments is a means of providing additional opportunities for teachers to increase the problem solving ability of students (Shoulders & Myers, 2012). Although opportunities exist for teachers to design rigorous laboratories that teach scientific problem solving (Parr & Edwards, 2004), little evidence exists on how they are used (Shoulders & Myers, 2012) or the effect that they have on student achievement.

Recent research suggests that the timing of an experience does not matter when measuring student learning by way of criterion-referenced tests; rather, what does matter is the type of reflection (Baker, Brown, Blackburn, & Robinson, 2014). If teachers desire to see effects on student performance, they must be present during the laboratory experience by constantly pushing students to reflect-in-action (Baker et al., 2014). Shoulders and Myers (2012) concluded, "Experiential learning in agricultural laboratories has been established as an ideal method to teach scientific content and problem solving skills to agriculture students . . ." (p. 135).

Cognitive style is another variable that may hold potential in understanding how student's learn best. Cognitive style has been posited to be related to learning styles, specifically, the more adaptive students tend to be more reflective, while the more innovative prefer hands-on experiences (Kirton, 1994). Further, Lamm, Rhoads, et al. (2011) stated that cognitive style should always be considered as a variable of interest when the goal is to improve student achievement. Therefore, the principal question that arose from the review of the literature was: "what effect does the type of reflection and students' cognitive style have on their performance on a criterion-referenced exam?"

Theoretical Framework

This study was framed around Kirton's (2003) Adaption-Innovation Theory (KAIT) and Kolb's (1984) experiential learning theory (ELT). The core of KAIT is that all individuals are creative and all solve problems. However, how people *prefer* to solve problems can differ (Kirton, 2003). These differences are referred to as cognitive style, which is defined as "the preferred way in which people respond to and seek to bring about change" (Kirton, 2003, p. 43). Kirton (2003) purposefully described the differences between cognitive style and cognitive capacity. Cognitive style is the preferred manner in which people approach problems, while cognitive capacity is composed of characteristics, such as intelligence or learned competencies. Cognitive style is a stable characteristic that does not deviate due to time or experiences (Kirton, 2003).

Cognitive style is a continuum that ranges from "more adaptive" to "more innovative" (Kirton, 2003, p. 47). Those who are more adaptive prefer to solve structured problems and thrive when utilizing existing structure to solve problems. These problem solvers have a technical mindset and focus on the development of "better solutions" (Lamm et al., 2012, p. 20). Conversely, those who are more innovative prefer problems to be loosely structured and are less concerned with technical details; rather, they tend to produce ideas that push the boundaries of the current paradigm (Kirton, 2003). The ideas developed by those who are more innovative are aimed at producing "different solutions" (Lamm et al., 2012, p. 20).

Research has indicated that relationships exist between cognitive style and learning (Kirton, 1994). De Ciantis (as cited in Kirton, 1994) reported that more adaptive learners preferred a reflective learning style, while the more innovative favored an active style. This implies that "adaptors learn in a detailed, sequential, linear mode whereas innovators prefer the holistic 'here and now' approach which hands-on experience provides" (Kirton, 1994, p. 29). Relationships also exist between experiential learning and cognitive style (Lamm, Rhoads, et al., 2011).

The foundation of ELT is a four-step process where experiences are transformed into learning opportunities (see Figure 1). Specifically, the four steps in the learning process are (a) concrete experience, (b) reflective observation, (c) abstract conceptualization, and (d) active experimentation (Kolb, 1984). For learning to occur, learners must be guided through the full cycle; however, where the cycle begins for each student should not be a concern for teachers (Baker et al., 2014; Kolb, 1984). Lamm, Rhoads, et al. (2011) found that "those with a strong preference for abstract categorization (thinking) and active experimentation (doing) when learning had a very strong relationship with several critical thinking items" (p. 20). However, Baker et al. (2014) found no statistically significant difference in student content knowledge regarding the timing of when an abstract conceptualization occurred in the experiential learning model.

Although all four stages of the experiential learning process are critical for learning, one of the most important is allowing students opportunities to reflect on the experience (Phipps et al., 2008). Reflection has been referred to as "a mechanism for the construction of knowledge from experience" (McAlpine & Weston, 2000, p. 371). Additionally, researchers have noted the symbiotic relationship between learning and reflection, as a student's ability to reflect expands, so does learning (Andrusyszyn & Davie, 1997). Reflection allows students to re-live an experience in their own minds and "evaluate its relevance, nature, and complexity" (Phipps et al., 2008, p. 226). Specifically, teachers should ensure that students have the opportunity to reflect, whether in a group setting or individually (Phipps et al., 2008). Some students may feel more comfortable reflecting verbally in a social setting and others may prefer journaling as a means of reflection (Lamm, Cannon, et al., 2011).

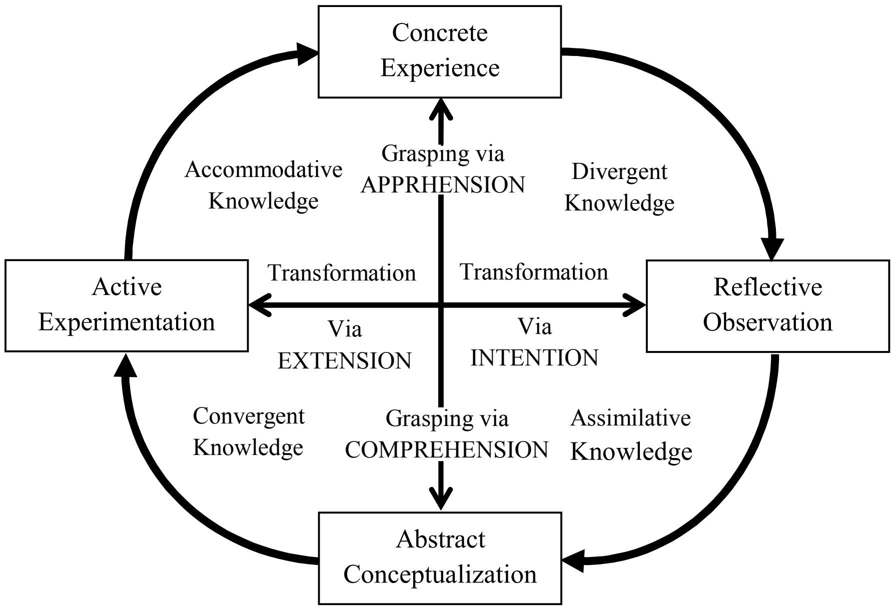

Figure 1. Model of Experiential Learning Process. Reprinted from *Experiential Learning: Experience as the Source of Learning and Development* (p. 42), by David A. Kolb, 1984, Englewood Cliffs, NJ: Prentice Hall, Inc. Copyright 1984 by Prentice-Hall, Inc. Reprinted with permission.

Schön (1983) described two types of reflection utilized by professionals to improve their practice: reflection-on-action and reflection-in action. Reflection-on-action describes reflective practices that occur following an experience. Reflection-in-action, however, occurs continuously during an experience (Schön, 1983). Baker et al. (2014) reported that students performed better on a criterion-referenced test when instructors guided them to reflect-in-action during an experience versus when allowed to reflect-on the experience.

A review of the literature revealed a gap related specifically to how different types of reflection-in-action affect student learning. Baker, Robinson, & Kolb (2012) reported that teachers play a crucial role in guiding students through the experiential learning cycle. The teacher facilitates reflection by "drawing out learners' interests, ideas, and previous knowledge" (Baker et al., 2014, p. 129). It is important to consider the effect that reflection may have on student achievement because "one form of reflective practice may not fit the needs of all students" (Lamm, Cannon, et al., 2011, p. 132). Additionally, cognitive style has been identified as an important variable when considering student achievement and learning (Kirton, 1994; Lamm, Rhoades, et al., 2011). Keeping in mind the importance of reflection in the experiential learning process, the principle question that arose from the review of the literature was, "What effect does type of reflection-in-action (verbal and written) and cognitive style (adaptive and innovative) have on student content knowledge when teaching experientially?"

This research study relates to Research Priority Area 4: Meaningful, Engaged Learning in All Environments (Doerfert, 2011). Specifically, this research relates to sub-bullet two, "examine the role of motivation, self-regulation, metacognition, and/or reflection in developing meaningful, engaged learning experiences across all agricultural education contexts" (Doerfert, 2011, p. 9). Deepening the understanding of how types of reflection-in-action affect student achievement is a critical component in addressing the challenges presented for this research priority area.

Purpose and Objectives

The purpose of this study was to determine the effects that type of reflection-in-action and students' cognitive style had on content knowledge. In addition, this study sought to determine how the interaction of type of reflection-in-action and students' cognitive style affected content knowledge. The following research objectives guided the study.

1. Determine the interaction effect of type of reflection-in-action and students' cognitive style on content knowledge.
2. Determine the effect of type of reflection-in-action on content knowledge.
3. Determine the effect of students' cognitive style on content knowledge.

The following null hypotheses guided the statistical analysis of the study.

$H_0$1: There is no statistically significant difference between students' content knowledge due to the interaction of type of reflection-in-action and students' cognitive style.

$H_0$2: There is no statistically significant difference in content knowledge of students due to the type of reflection-in-action received.

$H_0$3: There is no statistically significant difference in content knowledge between students' cognitive style.

Methods and Procedures

This exploratory, experimental study employed a completely randomized factorial (CRF) 2x2 design (Kirk, 1995). CRF designs are utilized when the effects of two independent variables, as well as their combined effects, are of interest (Ary, Jacobs, & Razavieh, 2002). The independent variables of this research study were type of reflection-in-action, either verbal or written, and students' cognitive style, either adaptive or innovative (Kirton, 2003). The dependent variable was students' content knowledge in biofuels, as measured on a 25-item criterion-referenced test, developed by the researchers.

The population of interest was all students (N = 57) enrolled in a junior-level foundations course in agricultural education at Oklahoma State University. G*Power was utilized to ensure sufficient power with the population of students and statistical procedures utilized (Faul, Erdfelder, Lang, & Buchner, 2007). Because the population consisted of pre-service teachers, this study was presented to the students within the course topic of teaching in and managing an agriscience laboratory and was included in the course syllabus. Early in the semester, students were made aware of this research study and its possible implications to them as future teachers. Once Institutional Review Board (IRB) approval was granted, students' cognitive style was assessed using Kirton's (2003) Adaption-Innovation Inventory (KAI). Additionally, students were administered a 10-item pre-test to determine students' biofuels content knowledge prior to completing the laboratory experience. An independent samples t-test was calculated to determine if pre-treatment differences existed between groups. A statistically significant difference (p = .718) did not exist between the *more adaptive* (M = 5.04) students and the *more innovative* (M = 4.84) students in terms of biofuels content knowledge prior to the treatment. Once the pre-test was administered, students were presented a 30-minute lecture and discussion on the role and purpose of biofuels to ensure all students were familiar with basic concepts and terminology.

Students were then assigned randomly, by cognitive style, to either the verbal or written reflection-in-action treatment groups.

Controlling threats to internal validity is a concern of researchers when designing experimental studies (Gay, Mills, & Airasian, 2009). A powerful control of threats to internal validity is random assignment to treatment groups (Gay et al., 2009). Random assignment to treatment groups has been called "the all purpose procedure for achieving pretreatment equality for groups" (Campbell & Stanley, 1963, p. 6). Campbell and Stanley (1963) described eight extraneous factors that can affect internal validity. These factors include history, maturation, testing, instrumentation, statistical regression, selection, experimental mortality, and selection-maturation interaction.

Specifically regarding this study, seven of the factors were either not applicable or were controlled for by random assignment. Experimental mortality, however, did impact this study, due in part to the lengthy treatment period. The treatment began on September 19, 2012, with the administration of the KAI. On September 24, 2012, all students received the in-class lecture on biofuels and their purpose in agriculture. Students were assigned randomly to treatment groups and participated in a biofuels laboratory exercise on September 26, 2012. The students were separated by reflection type to different classrooms facilitated by an instructor familiar with the content, procedures of the biofuels laboratory procedures, and the type of reflection to be utilized. Students were tested on their knowledge of biofuels as a result of their participation in the laboratory exercises on October 1, 2012 (see Figure 1). Finally, on October 7, 2012, the researchers shared the data with the students regarding the findings of the study.

Cognitive Style		Verbal Reflection-In-Action	Written Reflection-On-Action
	More Adaptive	Treatment Group A *n* = 16	Treatment Group B *n* =13
	More Innovative	Treatment Group C *n* = 9	Treatment Group D *n* = 10

Figure 1. Random Assignment to a CRF 2x2 design.

All agricultural education students (*N* = 57) who were enrolled in a junior-level foundations course at Oklahoma State University were included in the study. However, it was determined, *a priori,* that if any student missed any of the class meetings in which the treatment was occurring, they would be deleted from the study. In all, nine students failed to complete all treatment levels. Gay et al. (2009) stated that experimental mortality becomes an issue when group characteristics are changed due to participant attrition. Therefore, a comparison of the whole class population and the participants was warranted. Regarding the gender of the entire class population, 28 (49%) of the students were male and 29 (51%) were female. Twenty-nine (51%) were *more adaptive*, 27 (48%) were *more innovative*, and one student never completed the cognitive style inventory. The gender of the participating group was 22 male (46%) and 26 female (54%), and the cognitive style composition of the participating group was 29 *more adaptive* (60%) and 19 *more innovative* (40%) (see Figure 1).

The agriscience laboratory experiment employed a kit designed by Lab-Aids® titled, *Biofuels: Investigating Ethanol Production and Combustion.* Specifically, students completed investigation two, titled, *Comparing the Energy Stored in Two Fuels* (Lab-Aids® Kit 39S, 2007). In this investigation, students compared the energy levels of two fuels – ethanol and kerosene. To accomplish this task, students formulated hypotheses based on their current knowledge and prior experiences, and then completed the experimental investigation. The students were required to employ mathematical formulae and calculations for testing their hypotheses. The major scientific and mathematical concepts within this investigation included the chemical make-up of fuels, pollutants, experimental design and control, converting units of measurement, and averaging. Students in both groups were provided laboratory protocols based on the Lab-Aids® investigation to ensure fidelity of the treatment.

Reflection Treatment

Lamm, Cannon, et al. (2011) suggested that educators should be prescriptive in their expectations for students who reflect in writing. The authors recommended that educators should set aside time for reflective activities and that the questions should be clear and focused rather than loose and open-ended. Therefore, during the biofuels laboratory experiment, students in the written reflection-in-action group were provided laboratory protocols that guided them through their reflection of the activity. Students were required to stop working on the experiment and write a reflection, based on prescribed prompts, at seven points during the investigation, which equated to about every 15 minutes. Students were instructed to complete their written reflections individually.

In contrast, students in the verbal reflection-in-action group were not forced to stop and reflect in writing. Instead, the laboratory instructor asked probing questions throughout the investigation. The instructor was a graduate student and former secondary agriculture teacher who was trained to employ questioning techniques. These questions were similar to those of the written reflection-in-action group. The instructor asked questions purposefully, requiring students to stop working and reflect on the current situation verbally, as a group. The instructor utilized questioning techniques to ensure that all students had an opportunity to respond to questions. As such, this group was more social in nature when compared to the written reflection group. This strategy was employed in an attempt to polarize the treatment groups as much as possible.

Cognitive Style Treatment

Cognitive style was also a variable of interest in the study. Data were collected using Kirton's (2003) Adaption-Innovation Inventory (KAI). The KAI is comprised of 32-items used to measure people's preferred problem solving ability. According to Kirton (2003), scores may range between 32 and 160, with a theoretical mean of 96. Individuals who score a 95 or below are considered *more adaptive* and those who score a 96 or higher are considered *more innovative* (Kirton, 2003). The KAI was designed to be utilized with working adults; however, it has been used in a variety of additional contexts, including with teenagers and in educational settings (Kirton, 2003). Numerous studies have been conducted to establish the reliability of the KAI. Typical reliabilities have ranged from .74 to .86 for teenagers and .84 to .91 for working adults (Kirton, 2003). Because a variety of studies describe the reliability of the KAI, a pilot test was not conducted. Instead, post-hoc reliability estimates were conducted and yielded a Cronbach's alpha coefficient of .79 for this sample of undergraduate students, indicating the instrument was reliable for this population.

Content Knowledge Assessment

The researchers developed a 25-item criterion-referenced test to assess biofuels content knowledge. Test items were based on content and questions found in the Lab-Aids ® curriculum. The Lab-Aids ® curriculum comes complete with a booklet of scripted laboratory exercises for students to complete. Specifically, the booklet was used to develop questions for the biofuels criterion-referenced test. Once complete, a panel of experts assessed the face and content validity of the test. In particular, three pedagogical experts reviewed the test for ease of reading, semantics of questions, and general construction of the questions. An expert in biofuels reviewed the test for content appropriateness. The panel made minor recommendations for clarity and readability. All recommendations were accepted from the panel of experts prior to the release of the test to the participants.

Further, Wiersma and Jurs (1990) listed eight factors that should be accounted for by researchers to ensure reliability of criterion-referenced tests. Table 1 includes the factors as well as the researchers' attempts at addressing them. Because each of the eight factors described by Wiersma and Jurs (1990) were addressed, the test was deemed reliable (see Table 1).

Table 1

Examples of how the Eight Factors, Identified by Wiersma and Jurs (1990), Necessary for Establishing Reliability of Criterion-referenced Tests, were Addressed

Factor	How Factors were Addressed
1. Items should be homogeneous	Items included in the examination were of the same font size and style; thus, consistency was evident.
2. Items should be discriminating	A wide range of difficulty was included within the test, as directed by the content expert in biofuels.
3. A good quantity of items should appear	The test included 25 items that consisted of multiple-choice questions.
4. Test should be of high quality	Attention was paid to the formatting of the test, as verified by the panel of experts. The test was copied on a laser printer.
5. Directions for students should be clear	Directions were read aloud and were also printed at the top of the booklets provided to students.
6. Test should be administered in a controlled setting	The test was taken in the same room in which students attend lecture, so as not to change the climate in which students were conditioned.
7. Include strategies to motivate students to participate	Students were informed that the findings of this study would benefit them as future teachers regarding how to teach in laboratory settings to students with different cognitive styles.
8. Directions for scorer should be clear and easy to interpret	An answer key was developed and provided to the scorer to ensure the questions were assessed accurately.

Popham and Husek (1969) argued that internal reliability estimates are not appropriate for criterion-referenced tests because the instrument compares individuals to specific criteria and not to other individuals. However, Kane (1986) stated that internal consistency is an important issue related to criterion-referenced tests. Specifically, Kane (1986) discussed that internal reliability coefficients above .50 indicate the instrument would reflect students' aggregated mean scores accurately. Therefore, the Kuder-Richardson (KR-20) formula was utilized to calculate an initial reliability coefficient of .61 for the 25-item criterion referenced test.

A two-way independent analysis of variance (ANOVA) was employed to calculate the main and interaction effects of the independent variables (Field, 2009). ANOVA allows for the partitioning of variance associated with the treatment, as well as that associated with error (Ary et al., 2002). To determine the statistical significance of the research findings, an *a priori* alpha level was set at .05. The alpha level was utilized to determine whether or not to reject each null hypothesis (Kirk, 1995). Practical significance was determined by calculating effect size via partial eta squared (η_p^2). Kirk (1995) defined practical significance as whether the treatment effect is "large enough to be useful in the real-world" (p. 64). Interpretations of the η_p^2 statistic were made using the following guidelines: (a) 0.0099 indicating a *small* effect size, (b) 0.0826 indicating a *medium* effect size, and (c) 0.20 indicating a *large* effect size (Cohen, 1988).

Findings

Table 2 lists means and standard deviations by type of reflection-in-action and cognitive style. A total of 25 students participated in the verbal reflection-in-action group. The mean score of these students was 15.12 (*SD* = 3.08). Sixteen of those students were in the *more adaptive* category. These students' mean score was 15.44 (*SD* = 3.16). Nine students were considered *more innovative*. The mean test score of this group was 14.56 (*SD* = 3.05).

A total of 23 students participated in the written reflection-in-action group. The mean score of these students was 16.04 (*SD* = 4.07). The *more adaptive* students in this group scored an average of 15.46 (*SD* = 4.29), while the *more innovative* mean score was 16.80 (*SD* = 3.85). Overall, the *more adaptive* students had a mean score of 15.45 (*SD* = 3.64) and the *more innovative* scored an average of 15.74 (*SD* = 3.59).

Table 2

Mean Knowledge Test Scores for Treatment Conditions Type of Reflection-in-Action and Students' Cognitive Style

Type of Reflection In-Action	Cognitive Style	*M*	*SD*	*n*
Verbal Reflection	More Adaptive	15.44	3.16	16
	More Innovative	14.56	3.05	9
	Total	15.12	3.09	25
Written Reflection	More Adaptive	15.46	4.30	13
	More Innovative	16.80	3.85	10
	Total	16.04	4.07	23
Total	More Adaptive	15.45	3.64	29
	More Innovative	15.74	3.59	19
	Total	15.56	3.58	48

Prior employing the two-way ANOVA, Levene's test of equality of error variances was employed to ensure the assumption of equal variances was not violated. Levene's test was determined to be non-significant at the .05 level, $F(3, 44) = 0.76$, $p = .52$. ANOVA was then utilized to determine main and interaction effects (see Table 3). The interaction effect of type of reflection-in-action and cognitive style yielded an $F(1,44) = 1.07$, $p = 0.31$. The interaction effect was deemed non-significant and the researchers failed to reject the first null hypothesis. An analysis of main effects was necessary because no interaction effect was detected (Kirk, 1995).

Regarding type of reflection-in-action, the ANOVA yielded $F(1,44) = 1.12$, $p = 0.30$. Therefore, the main effect of type of reflection was determined to be non-significant; thus, the researchers failed to reject the second null hypothesis. Further, there was no statistical significance of the main effect of cognitive style, $F(1, 44) = 0.05$, $p = 0.83$. Therefore, the researchers failed to reject the third null hypothesis (see Table 3).

Table 3

Analysis of Variance Summary Table

Source	*SS*	*df*	*MS*	*F*	*p*	η_p^2*
Reflection	14.68	1	14.68	1.12	.30	-
Cognitive Style	.60	1	.60	.05	.83	-
Reflection* Cognitive Style	14.07	1	14.07	1.07	.31	-
Error	578.99	44	13.16			
Total	12229.00	48				

**Note.* Practical significance is not reported when *p* is not statistically significant.

Conclusions

Regarding the type of reflection in which students were exposed, the researchers were pleased to learn that, per Schön's (1983) reflection-in-action theory, the type of reflection did not affect test scores. Teachers, therefore, should not concern themselves about the way in which they guide students to reflect-in-action; rather, they should focus on providing options for students to reflect that will "accommodate a variety of learning styles when trying to guide students through the experiential learning cycle" (Lamm, Cannon, et al., 2011, p. 132). It is important for teachers to reflect during the experiences with their students (Baker et al., 2014), in whatever mode that suits them best.

The findings of this study also suggest that students' cognitive style has no effect on their ability to perform on a knowledge-based test. This finding supports Kirton's (2003) adaption-innovation theory suggests that students' cognitive style is not an indicator of intelligence; rather, it is an indicator of their preference for solving problems. It is comforting to know that students were able to achieve at similar levels, regardless of their cognitive style.

Finally, there was a lack of simple main effects in the study. Specifically, the variables of cognitive style and the type of reflection-in-action did not interact with one another. This finding suggests that neither cognitive style nor type of reflection-in-action had a bearing on students' performance on the criterion-referenced test. Kirton (1994) posited that the more adaptive would prefer a reflective learning style, while the more innovative would prefer a more hands-on, experiential approach. Perhaps employing reflective exercises during an experientially based learning activity enabled both the more adaptive and more innovative to learn the biofuels content at similar levels.

Recommendations for Research

The findings of this study indicate that cognitive style and type of reflection-in-action do not affect students' knowledge scores in an agriscience laboratory. However, because this study was exploratory in nature and employed a rather small sample size (n = 48), further research should occur (Kirk, 1995). It is recommended that the study be replicated with a larger sample size to confirm or refute the findings of this exploratory study. This study utilized a short pretest to determine if groups varied in content knowledge prior to the treatment. Future studies should utilize a true pretest/post-test design to determine change in content knowledge attributable to the intervention.

Much of the literature surrounding KAI has been focused on group problem solving. This study focused on individual student performance. Future studies should also compare how teaming students together in pairs of similar and different cognitive styles affects their problem solving ability and achievement on tests. Future research should investigate if cognitive diversity influences group problem solving, as well as student achievement. For instance, how do students who are paired together with similar cognitive styles, such as adaptive-adaptive (A-A) and innovative-innovative (I-I), compare to each other? Likewise, what about students who are paired together according to dissimilar cognitive styles, such as adaptive-innovative (A-I)? Do A-I pairs outperform A-A and I-I pairs on criterion-referenced tests and problem solving exercises? Kirton (2003) indicated that individuals who have a large cognitive style gap are more likely to experience frustrations and are forced to utilize coping behaviors to accomplish tasks. Further research should explore these phenomena because the potential findings could have implications for how teachers pair students together in various team-centered activities, such as cooperative learning activities or career development events.

Research should investigate the effect that cognitive style has on students' ability to solve problems accurately and efficiently. Do the *more adaptive* solve problems more efficiently than the *more innovative*? Research should also assess whether cognitive style influences students' ability to solve both ill-defined and structured problems regarding various real-life problems in the context of agriculture. More generally, studies should examine the impact of cognitive style on students' critical thinking, problem solving, and metacognitive skills.

Finally, this study should be replicated at the secondary level to determine the effects it has on students in school-based programs. Parr and Edwards (2004) recommended that "more empirically-based research should be conducted to explore teachers' use of the problem-solving approach in the context of secondary agricultural education and subsequent student achievement in science" (p. 113). As such, replicating this study offers a means for achieving this purpose.

Recommendations for Practice

This study was conducted using pre-service teachers as a means to teach them about the experiential learning method through application of an agriscience laboratory experiment. As such, the researchers should share the knowledge found in this study with current and future agricultural education majors in the teacher preparation program at Oklahoma State University. Specifically, teacher educators should reinforce the importance of reflection in the learning process. Per Baker et al. (2014), reflection-in action is more effective that reflection-on action when teaching experientially. The current study revealed that both verbal and written reflection-in action were equally effective in terms of student achievement on a criterion-referenced test.

Opportunities also exist for in-service training regarding the use of experiential learning as an effective pedagogy in teaching laboratory-based experiences (Baker et al., 2014). Specifically, summer workshops should be conducted that manipulate similar treatment variables with current agriculture teachers. This type of workshop would help expose agriculture teachers to important content that could be, and perhaps should be, taught in agricultural power and technology or natural resources courses.

Limitations

This study was limited in size and scope. In an ideal situation, the researchers would have recruited additional students to participate in the study to improve the study's power. However, the study was conducted as an activity included in the course syllabus to teach pre-service teachers more about scientific problem solving in a laboratory setting. As such, the researchers were restricted on sample size based on the number of students enrolled in the course.

Another limitation was the length of time in which students tested after participating in the treatment. Students finished the treatment on a Wednesday but did not take the test until the following Monday. This delay was due to the course schedule, as the course meets on Monday and Wednesday mornings. As such, it is fair to assume that mortality occurred. Also, comparisons of gender and cognitive style were made to determine if the characteristic of the participating group differed from the entire class population. Although little differences existed between the groups based on gender, a higher proportion of the *more innovative* students failed to complete all treatment conditions, which could have affected the study's outcomes.

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